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The Effects of Opuntia (Cactaceae) on Lowering Postprandial Blood Glucose

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Abstract

Background: The rise of chronic diseases such as diabetes, cardiovascular disease, and obesity has become a great concern in the medical community. Incorporating *Opuntia* into people's diets may allow patients a natural alternative to supplement traditional medicine in order to combat these diseases. The purpose of this review is to investigate the effect of *Opuntia* on postprandial glucose levels.

Methods: A comprehensive search of online medical literature was performed using MEDLINE-PubMed, EBMR Multifile, and CINAHL. Keywords used included: prickly pear, nopal, *Opuntia*, and diabetes. Inclusion criteria required human studies, studies published in the English language, and studies within the last 15 years.

Results: Three articles met eligibility criteria. Two of the articles were cohort studies while one of the studies was a randomized control trial. There are consistent results regarding a significant decrease in postprandial insulin and blood glucose levels. The overall quality of the studies is low due to some limitations (see Table I). Further studies are needed to address these limitations, and improve the quality of evidence in regards to the effects of *Opuntia* on postprandial blood glucose.

Conclusion: Studies investigating the effects of *Opuntia* on postprandial glucose levels show promising results of safely lowering postprandial blood glucose and insulin levels acutely. However, more research is needed with larger randomized controlled studies to provide additional evidence to support these results. Additional research is also needed to determine the long-term effects of *Opuntia,* and its capability to complement and potentially replace traditional hypoglycemic medications. Until then, medical providers can discuss *Opuntia's* natural hypoglycemic effects with patients to help reduce progression of chronic disease.

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Prickly pear, nopal, Opuntia, postprandial, diabetes.

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Biography

Megan Aaseby was raised in Iowa and graduated from Western Illinois University in 2011 with a degree in Marketing. She worked for a government IT command center during her undergrad years. After completion of her undergraduate degree, she moved to New York and worked as a business analyst in information technology. After working in IT for a couple of years she decided to make the transition to medicine and relocated to North Carolina to pursue additional coursework in Biology. She also volunteered at the emergency department and neonatal intensive care unit, and worked as a CNA before starting PA school.

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List of Abbreviations

ANOVA	Analysis of Variance
Apo B	Apolipoprotein B
BMI	body mass index
BUN	Blood Urea Nitrogen
CAM	Complementary and Alternative Medicine
CH	Cholesterol
ELISA	Enzyme-Linked Immunosorbent Assay
GFR	Glomerular Filtration Rate
GIP	Glucose-Dependent Insulinotropic Peptide
GLP-1	Glucagon-Like Peptide-1
HCB	High-Carbohydrate Breakfast
HDL-CH	High-Density Lipoprotein Cholesterol
hs-CRP	High Sensitivity C-Reactive Protein
HSPB	High-Soy-Protein Breakfast
IAUC	Incremental Area Under the Curve
kcal	Kilocalorie
KJ	Kilojoules
LDL-CH	Low-Density Lipoprotein Cholesterol
MCH	Mean Cell Hemoglobin
MCHC	Mean Cell Hemoglobin Concentration
MCV	Mean Cell Volume
min	minutes
NCCAM	National Center for Complementary & Alternative Medicine
OGTT	Oral Glucose Tolerance Test
RBC	Red Blood Cell
RCT	Randomized Controlled Trial
RDW	Red Cell Distribution Width
TG	Triglyceride
WBC	White Blood Cell

The Effects of *Opuntia* (Cactaceae) on Lowering Postprandial Blood Glucose

BACKGROUND

The cactus *Opuntia*, which is also known as prickly pear cactus, Indian fig cactus, or nopal is native to central Mexico and is a commonly eaten vegetable. The cladodes, commonly called pads, nopalitos, or tunas, are traditionally used for the treatment of diabetes in traditional Mexican medicine. In the late 1980's, Frati-Munari et al[1] was one of the first to investigate in humans the hypoglycemic effect of prickly pear pectin in different patient groups. Several studies[2-4] have been performed which support the hypoglycemic effects of *Opuntia*, but few have focused on the effects of *Opuntia* on postprandial blood glucose.

With the rise of chronic disease such as diabetes, cardiovascular disease, and obesity there has been a great concern in the medical community about the limited resources for prevention and treatment. Consuming high-calorie meals can lead to exaggerated postprandial peaks in blood glucose and lipids in diabetics which results in inflammation and endothelial dysfunction.[5] Incorporating *Opuntia* into people's diets may allow patients a natural alternative to supplement traditional medicine. *Opuntia* can be a safe way to counteract

increases in postprandial blood glucose to prevent further health complications of diabetes and cardiovascular disease.

Clinicians need to be knowledgeable about herbal remedies to provide guidance to patients who are looking for traditional medicine options to improve adherence and if possible to reduce progression of chronic diseases. The purpose of this review is to investigate the effect of *Opuntia* on postprandial glucose levels, and to determine if *Opuntia* should be recommended as a natural alternative for lowering postprandial glucose.

METHODS

A comprehensive search of online medical literature was performed using MEDLINE-PubMed, EBMR Multifile, and CINAHL. The keywords used during this search included: prickly pear, nopal, *Opuntia*, and diabetes. Eligibility criteria required were human studies, studies published in the English language, and studies within the last 15 years. Other inclusion criteria required patients that consumed *Opuntia*. Studies were excluded if they did not include postprandial data on blood glucose and insulin. The quality of relevant articles was evaluated using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group guidelines.[6]

RESULTS

An initial search of MEDLINE-Pubmed yielded 60 articles for review. After screening the results for relevant articles, 3 of the articles[1,5,7] met eligibility criteria. One of the studies[7] was a randomized control trial, while 2 of the articles were cohort studies[1,5]. An initial search on EBMR Multifile yielded 5 articles. After screening the results only one article[5] met the criteria, but this study already appeared in the MEDLINE-Pubmed results. A search on CINAHL revealed 18 results. After screening the results only one article[5] met the criteria, but the one already appeared in the MEDLINE-Pubmed results. In total, 3 articles were assessed for this systematic review (See Tables I-IV).

Godard et al (2010)

This 16-week double-blind placebo controlled study[7] was designed to evaluate the acute and chronic effects of OpunDia™ (*Opuntia ficus-indica*) in 29 pre-diabetic obese male and female subjects. Inclusion criteria was a body mass index 30-35 kg/m^2, and an oral glucose tolerance test (OGTT) with a 2-hour OGTT value between 140 and 199 mg/dL. Subjects were excluded if they had any known health problems such as hypertension, kidney, or liver problems or were pregnant or nursing women. In addition, subjects

regularly taking any prescription or non-prescription drugs including dietary supplements were excluded.[7]

The participants (ages 20-50 years) were randomly assigned to 1 of 2 groups and given a 16-week supply of either 200mg OpunDia™ (n=15) or placebo (n=14). The proprietary product OpunDia™ is a blend of *Opuntia ficus-indica cladode* and fruit skin extract. All the plant materials of *Opuntia ficus-indica* were obtained from a US American-based cultivation. The OpunDia™ supplement consisted of capsules containing 200 mg OpunDia™. Capsules containing 200 mg microcrystalline cellulose were used as a matched-placebo.[7]

Baseline and post 16-week concentrations of glucose, insulin, high sensitivity C-reactive protein (hs-CRP), adiponectin, proinsulin, Hb1Ac, adiponectin cholesterol, and comprehensive metabolic panel were collected. Analysis of variance (ANOVA) was used repeatedly throughout the study to determine any significant interactions between group and time.[7]

During the acute study phase, an OGTT with a bolus load (400 mg) of OpunDia™ was given 30 minutes (min) before ingestion of a 75 g glucose solution. Blood samples were drawn before the bolus administration, before the ingestion of the glucose solution, and every 30 min thereafter for 120 min. Results were analyzed with an overall significance level set at 5%. There was a statistical significant

difference (P<0.05) in blood glucose concentrations between the pre-diabetic OGTT values and the OGTT values after OpunDia™ bolus administration after 60 min (206 ± 37 mg/dL versus 189 ± 38 mg/dL), 90 min (185± 34 mg/dL versus 170 ± 35 mg/dL) and 120 min (159 ± 18 mg/dL versus 149 ± 25 mg/dL).[7]

For the chronic study phase, the following blood parameters were determined via enzyme-linked immunosorbent essay (ELISA) kits before and after the 16-week supplementation period: OGTT, plasma levels of glucose, insulin, hs-CRP, adiponectin, proinsulin, and glycosylated hemoglobin. The OpunDia™ group had significantly lower blood glucose concentrations (via the OGTT) at 60, 90, and 120 min post-intervention compared to pre-intervention. However, the placebo group also demonstrated significantly lower blood glucose concentrations at the 60 and 120 min time points post-intervention compared to pre-intervention. There was no between-group difference found with any of the other blood chemistry variables.[7]

The chronic phase of the study did reveal the safety of OpunDia™. The following blood parameters were determined before and after the 16-week supplementation period to determine the safety of OpunDia™: blood urea nitrogen (BUN), creatinine, glomerular filtration rate (GFR), BUN/creatinine ratio, protein total, albumin, globulin, albumin/globulin ratio, bilirubin total, white blood cell (WBC)

count, red blood cell (RBC) count, hemoglobin, hematocrit, mean cell volume (MCV), mean cell hemoglobin (MCH), mean cell hemoglobin concentration (MCHC), red cell distribution width (RDW), platelet count, and WBC differential. The study showed neither relevant side effects or negative side effects on blood, liver or kidney parameters.[7]

Lopez-Romero et al (2014)

This was a cohort study[5] done to determine the effect of nopal on postprandial glucose in Mexican patients with type 2 diabetes. Two studies were performed. Each study used a separate group of participants. All participants completed a 12-hour overnight fast and consumed the test meal(s) in the morning within 10 min.[5]

Capillary blood samples were taken using a finger-stick to measure glucose in healthy participants intermittently before and at 15, 30, 45, 60, 90, and 120 min after consuming the test meals. Diabetic patients received an additional sample collection at 150 min. In addition, venous blood samples obtained at the same intervals as capillary blood to measure serum insulin, plasma glucose-dependent insulinotropic peptide (GIP), glucagon-like peptide-1 (GLP-1) and antioxidant activity. A *P* value of <0.05 was considered to be significant.[5]

The first study was performed to determine the glycemic index of nopal. Participants included 7 healthy, nonsmoking, nonmedicated,

normal-weight volunteers (3 men and 4 women) with a standard error of mean [SEM]= 26.3±1.2 years of age and a mean±SEM body mass index (BMI) of 23.5±0.8 kg/m2. The glycemic index, insulinemic index, GIP index and GLP-1 index were calculated after participants consumed 50 g of available carbohydrates from glucose or dehydrated nopal. The results showed ingestion of 50 g of available carbohydrates from nopal resulted in a significant reduction (P <0.001) in the incremental area under the curve (IAUC) of blood glucose with respect to the 50 g of glucose, which resulted in a low glycemic index for nopal. As for insulin, the IAUC for nopal was significantly different (P <0.05), which resulted in a insulinemic index that was also considered low.[5]

The second study was performed to evaluate the effect of nopal on postprandial blood glucose after the consumption of 2 different types of breakfasts with or without 300 g steamed nopal. There was a washout period of 1 week between meals. Participants included 14 diabetics (4 men and 10 women) who were diagnosed with type 2 diabetes less than 8 years before enrollment. Subjects were between 40-60 years old with a BMI <30. This study excluded subjects with dyslipidemia, hypertension, or severe hypoglycemic episodes during the past year. Their fasting serum glucose concentration were <8%. The only treatments the diabetics were receiving was metformin.

However, the day of the study, participants were instructed not to take their morning doses of metformin.[5]

Seven non-diabetics were recruited for this study for the control group. This group included 4 men and 3 women (25-54 years old) with a BMI $\leq$25 for the past 6 months. Exclusion criteria for this control group included current cigarette smokers, presence of known medical problem or currently being on any medication.[5]

This study evaluated the metabolic effect of steamed nopal on postprandial peak of glucose, insulin, GIP, and antioxidant activity after the consumption of a high-carbohydrate breakfast (HCB) or high-soy-protein breakfast (HSPB). The HCB contained 300 kilocalorie (kcal) and comprised of 89% carbohydrates, 6% protein, and 5% fat. The HSPB contained 344 kcal and comprised of 42.4% carbohydrates, 40.7% protein and 16.9% fat. The HCB+nopal and the HSPB+nopal contained the addition of 300 g steamed nopal.[5]

Results show that patients with type 2 diabetes had a higher fasting blood glucose concentration compared with healthy individuals. Patients with type 2 diabetes who consumed the HSPB avoided postprandial blood glucose peaks. HSPB+nopal significantly reduced the postprandial peaks of GIP concentration at 30-45 min and increased the antioxidant activity after 2 hours measured by the 2,2-diphenyl-1-picrilhidracyl method.[5]

Patients with type 2 diabetes who consumed the HCB+nopal were significantly lower area under the curve for glucose than for insulin. HCB+nopal significantly decreased the postprandial peaks of glucose at 45 and 60 min (P <0.01). The IAUC for HCB+nopal was significantly lower than the group with an HCB (<0.001).[5]

The addition of nopal significantly decreased the postprandial peaks of glucose at 30, 45 and 60 min (P <0.05). There was no difference in the IAUC for glucose in healthy participants after the consumption of both breakfasts.[5]

These findings suggest that nopal could reduce postprandial blood glucose, serum insulin, and plasma GIP peaks, as well as increase antioxidant activity in healthy people and patients with type 2 diabetes.[5]

Wolfram et al (2002)

In this cohort study,[1] the goal was to determine the effect of prickly pear (*Opuntia robusta*) on glucose and lipid metabolism in lean, non-diabetics with hyperlipidemia. Twenty-four non-diabetic, non-obese males (37-55 years old) with normal BMI were split up into 2 groups. Group A consisted of 12 men with primary isolated hypercholesterolemia, and Group B consisted of 12 men with combined hypercholesterolemia and hyperlipidemia.[1]

In phase I, an 8-week 7506 kilojoules (KJ) step-1 diet was completed. The diet provided to participants was constant through all study phases. In phase II, 625 KJ (50% from fibers and 50% from carbohydrates) were replaced by *Opuntia robusta* edible pulp (250g/day) for 8 additional weeks. The prickly pear was locally grown. Blood was drawn at the beginning and end of each phase. Additionally, blood was drawn at the end of phase II in the morning after a 14-hour overnight fast. Blood chemistry included: lipids, lipoproteins, apolipoproteins, lipoprotein-a, fibrinogen, uric acid, blood glucose and serum insulin. A confidence level of 95% and t-tests were performed. P-values smaller than 0.05 were considered statistically significant.[1]

The comparison of the mean values at the end of phase I and II showed the prickly pear caused a decrease of blood glucose (11%), insulin (11%), total cholesterol (12%), low-density lipoprotein-cholesterol (15%), apolipoprotein B (9%), triglycerides (12%), fibrinogen (11%), and uric acid (10%). Meanwhile, body weight, high-density lipoprotein-cholesterol, apolipoprotein A-1, and lipoprotein-a remained unchanged.[1]

There was a significant decrease in both groups between the mean values of phase I and II including blood glucose, total cholesterol (CH), low-density lipoprotein cholesterol (LDL-CH), apolipoprotein B (apo B), fibrinogen, and uric acid. Triglyceride (TG)

levels only showed a significant decrease in Group B, while high-density lipoprotein cholesterol (HDL-CH) increased significantly ($p<0.01$) only in group A. Insulin levels were significantly lowered in group A, while group B showed no significant changes in insulin. No changes in body weight or BMI were observed during the study.[1]

DISCUSSION

The modern western diet and lack of physical activity has created an environment for unhealthy lifestyles that is leading to a rise in chronic diseases such as diabetes, cardiovascular disease, and obesity. Uncontrolled postprandial blood glucose levels are a serious health problem for individuals with chronic diseases. Clinicians and patients are in need of an easy and cost effective solution to this problem.

Some patients are more likely to adhere to natural remedies than take a pill. In the last two decades, complementary and alternative medicine (CAM) has increased significantly.[8] The National Center for Complementary and Alternative Medicine (NCCAM) defines CAM as "healthcare and medical practices that are not currently an integral part of conventional medicine."[8,9] Commonly used CAMs are herbal therapies, multivitamins, prayer, acupuncture, yoga and aromatherapy, among others. Patients with chronic conditions such as

diabetes, hypertension, cancer, arthritis, and asthma are more likely to use CAM than the general public.[9] Although many patients with chronic conditions use CAM in attempt to improve their chronic conditions, there are few studies that analyze the prevalence and types of CAMs available, as well as their use among various ethnic and cultural backgrounds.

Nopal is a commonly used food and traditional remedy among people of Mexican descent. Many studies have recognized prickly pear's effects as an herbal hypoglycemic agent but few studies have examined its postprandial glycemic effects. These 3 studies[1,5,7] demonstrate that prickly pear may be efficacious and likely safe in lowering postprandial blood glucose in both type 2 diabetics and non-diabetics, and has significant benefit on human lipid metabolism.[1] Godard et al[7] had a statistically significant decrease ($P<0.05$) in blood glucose concentrations after the consumption of OpunDia™ with prediabetic patients at the 60, 90 and 120 min time points (see Table II). Lopez-Romero et al[5] study had a statistically significant decrease ($P<0.05$) in postprandial blood glucose at 30, 45 and 60 min in diabetic patients that consumed HCB+nopal for breakfast (see Table III). Wolfram et al[1] study also found a statistically significant decrease ($p<0.005$) in blood glucose among non-diabetics with hyperlipidemia with and without hypercholesterolemia (see Table IV).

Nopal was shown to also decrease insulin levels in diabetics,[5] and non-diabetic hyperlipidemia patients,[1] but did not have a statistically significant effect on insulin in pre-diabetics[7] or hyperlipidemia plus hypercholesterolemia patients.[1] Although the mechanism of action of prickly pear's hypoglycemic effects are unknown, there is significant decrease of serum insulin occurring throughout these studies that may suggest prickly pear increases a cell's sensitivity to insulin. In the Lopez-Romero et al[5] study their research suggest that nopal could regulate blood glucose and serum insulin concentrations by modulating GIP levels after finding nopal's low glycemic index and insulinemic index were associated with a dramatic reduction of the IAUC for the total plasma GIP concentration.[5]

It is difficult to compare which participants had the largest decrease due to the variability of the studies, but when taking into consideration all the variables, prickly pear appeared to be more effective in pre-diabetics and diabetics than healthy, non-diabetics. Since the quality of these studies is low, prickly pears have potential to make an impact on reducing the effects of chronic disease. Thus, clinicians could consider recommending *Opuntia* be added to diets in patients with chronic diseases such as diabetes, pre-diabetes, obesity, heart disease, hyperlipidemia, and hypercholesterolemia.

The main limitations of the studies included in this systematic review are lack of large sample-sizes, lack of randomization in the placebo controlled trial, and lack of control groups. Although the studies were consistent with the *Opuntia* samples used in the studies, each of the 3 studies consumed a different type of *Opuntia* that was prepared and served in different amounts between the studies.

Although nopal is a widely consumed vegetable that is considered safe, more research is needed to determine its safety in individuals with severe liver or kidney disease and pregnant or nursing women. Further research is also needed to investigate effects of prickly pear. More randomized controlled trials (RCTs) are needed to validate these results, determine the long-term effects of prickly pear, and test if an increased dose may cause more noticeable effects on postprandial blood glucose. Additional research is needed to determine if *Opuntia* can be used to substitute common medications prescribed for type II diabetics, such as metformin. Recommending *Opuntia* in conjunction with clinical medicine may increase patient adherence among those that are hesitant to take medication or drastically change their diet, and reduce undesired outcomes caused by diabetes.

CONCLUSION

Overall, all 3 studies[1,5,7] show the acute postprandial blood glucose lowering effects on obese pre-diabetics, type II diabetics, and non-diabetics. It also showed the long-term safety of *Opuntia*, thus supporting its traditional use for blood glucose management. Studies investigating the effects of *Opuntia* on postprandial glucose levels show promising results on safely lowering postprandial blood glucose and insulin levels acutely. However, more research is needed with larger randomized controlled studies to provide additional evidence to support these results.

Additional research is also needed to determine the long-term effects of *Opuntia,* and its capability to complement and potentially replace traditional hypoglycemic medications. Until then, medical providers can discuss *Opuntia's* natural hypoglycemic effects with patients to help reduce progression of chronic disease.

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Table I. Quality Assessment of Reviewed Articles

Study	Design	Downgrade Criteria					Upgrade Criteria	Quality
		Limitations	Indirectness	Inconsistency	Imprecision	Publication bias		
Godard et al[7]	RCT	Very Serious[a,b]	Not Serious	Not Serious	Not Serious	Unlikely[c]	None	Low
Lopez-Romero et al[5]	Cohort	Very Serious[b]	Not Serious	Not Serious	Not Serious	Unlikely	None	Very Low
Wolfram et al[1]	Cohort	Very Serious[b,d]	Not Serious	Not Serious	Not Serious	Unlikely	None	Very Low

[a] Study lacks randomization.
[b] Small sample size.
[c] The funding for this research is not disclosed, nor is there a disclaimer from the makers of OpunDia™.
[d] Study lacks a control.

Summary Findings

Table II. Godard et al (2010)[7]

Study Characteristics					*Outcomes*: Comparing changes in outcomes between data (n.s = not significant; *Significant p-values <0.0.5)				
Groups	**Patient Population**	**Age in Years**	**Study Length**	**Prickly Pear Supplement**	**Blood Glucose (mmol/L) at 0 min**	**Blood Glucose (mmol/L) at 30 min**	**Blood Glucose (mmol/L) at 60 min**	**Blood Glucose (mmol/L) at 90 min**	**Blood Glucose (mmol/L) at 120 min**
Acute Phase n=15	Twenty-nine pre-diabetic male and female participants with no known health problems that are not taking any prescription or non-prescription drugs	20-50 years	120 min	400 mg OpunDia™ bolus	n.s.	n.s.	205.92 ± 36.90 mg/dL vs 188.84 ± 38.43 mg/dL*[a]	184.55 ± 33.67 mg/dL vs 169.74 ± 35.16 mg/dL*	159.24 ± 17.85 mg/dL vs 148.89 ± 24.86 mg/dL*
Chronic Phase n=15			16 weeks	2x200 mg OpunDia™ capsule	n.s.	n.s.	*[b,c]	*[c]	*[b,c]

[a] Blood glucose concentrations between the pre-OGTT values and the OGTT values after OpunDia™ bolus administration.
[b] The intervention group experienced significantly lower blood glucose concentration at 60 min, 90 min and 120 min time points compared to pre-intervention. However, the placebo group also demonstrated significant lower blood glucose concentrations at 60 and 120 min post intervention compared to pre-intervention.
[c] Pre-value OpunDia™ and post-value OpunDia™ glucose statistical data not included in the study.

Table III. Lopez-Romero et al (2014)[5]

Study Characteristics					*Outcomes*: Comparing changes in outcomes between data (n.s = not significant; *Significant p-values <0.05; **Significant p-values <0.01; ***Significant p-values <0.001)		
Groups	**Patient Population**	**Age in Years±SEM**	**Prickly Pear Supplement**	**Blood Samples**	**Blood Glucose (mg/dL)**	**Insulin (pmol/L)**	**GIP (pg/mL)**
Study 1 n=7	3 men and 4 female healthy non-diabetics, non-smoking, non-medicated, normal-weight volunteers	26.3±1.2 years	50 g glucose vs 50 g dehydrated nopal	Before meals and 15,30, 45, 60, 90, 120, and 150 min after meals	231.7±17.4 vs 71.4±3.5***	25.5±5.8 vs 7.8±1.0*	76.3±13.4 vs 12.5±17.3***
Study 2 n=21	4 men and 10 w diagnosed with type 2 diabetes with durations of <8 years and BMI <30	48±2.1 years	HCB vs HCB + 300 g steamed nopal		443±49 vs 287±30**	7,313±1091 vs 5,953±834*	n.s.
			HSPB vs HSPB + 300 g steamed nopal		n.s.[a]	n.s.	1744±258 vs 2,448±229**
	4 men and 3 female healthy non-diabetics, non-smoking, non-medicated, normal-weight volunteers	22.2±0.6 years	HCB vs HCB + 300 g steamed nopal		120.7±1.8 vs 106.3±5.4*	n.s.	8,252±1,171 vs 2,842±802**
			HSPB vs HSPB + 300 g steamed nopal		n.s.[a]	n.s.	n.s.

[a]There was no significant difference between the HSPB with and without nopal, however, the HSPB with and without nopal produced a smaller postprandial blood glucose peak than the HCB (P <0.001); and therefore, was more effective in reducing postprandial glucose peak.

Table IV. Wolfram et al (2002)[1]

Study Characteristics					*Outcomes*: Comparing changes in outcomes between data (n.s = not significant; *Significant p-values <0.01 & **Significant p-values <0.005)							
Groups	**Patient Population**	**Age in Years**	**Study Length**	**Prickly Pear Supplement**	**Blood Glucose (mmol/L)**	**Insulin (pmol/L)**	**TG (mmol/L)**	**Total CH (mmol/L)**	**LDL-CH (mmol/L)**	**HDL-CH (mmol/L)**	**Apo B (mmol/L)**	**Uric Acid**
Group A n=12	Non-obese males with Hypercholesterolemia	35-55 [mean 45±4.7]	16 weeks[a]	Controlled 7506 KJ diet vs Controlled 7506 KJ diet with 625 KJ replaced with of 250 g/day of prickly pear edible pulp consumed for 8 weeks	5.1 vs 4.49**[b]	72.6 vs 62**[b]	n.s.	7.2 vs 6.4**[c]	5.3 vs 4.5**[c]	1.27 vs 1.31*[d]	24.9 vs 22.5**[d]	364 vs 341**[b]
Group B n=12	Non-obese males with hypercholesterolemia & hyperlipidemia				5.27 vs 4.8**[b]	n.s.	n.s.	7.2 vs 6.3**[c]	4.4 vs 3.75**[c]	n.s.	27.9 vs 24.4**[d]	340 vs 289**[b]

[a] Phase 1: first 8 weeks with controlled 7506 KJ diet. Phase 2: Replaced 625 KJ with 250 g/day of prickly pear edible pulp consumed for 8 weeks.
[b] Outcome results estimated from Figure 3. Blood Glucose, Insulin and Uric Acid.
[c] Outcome results estimated from Figure 1. Total Cholesterol, Triglycerides, LDL-cholesterol and Fibrinogen.
[d] Outcome results estimated from Figure 2. HDL-Cholesterol and Apolipoprotein B.